

REPORT OF THE ENTOMOLOGIST.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., September 19, 1918.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1918. In accordance with your instructions, I have confined this report to concise statements of work performed during the year, with emphasis on the activities having a direct bearing on war problems.

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

DECIDUOUS-FRUIT INSECT INVESTIGATIONS.

Investigations of deciduous-fruit insects have been carried out under the direction of Dr. A. L. Quaintance, as in preceding years.

APPLE INSECT INVESTIGATIONS.

CODLING MOTH.—Biological studies of the codling moth have been continued, and a large amount of experimental work has been done in orchards bearing upon various practical points in the control of this serious pest. Spraying experiments, carried on in cooperation with the Colorado Agricultural Experiment Station, in the Grand Valley of Colorado, have indicated that a schedule of six applications of arsenate of lead at the rate of 4 pounds of the powdered product to 200 gallons of water, with the addition of 4 pounds of fish-oil soap, will make a very effective treatment for the orchards in that valley.

In the Rogue River Valley, Oreg., the codling moth is not only seriously injurious to apples, but causes a large loss by injury to pears. Therefore, in cooperation with the Oregon Agricultural Experiment Station, extensive studies were undertaken in the fall of 1917 with headquarters at Medford. This work was begun so recently that it is too early to report results.

At the same time this bureau and the Bureau of Plant Industry established a joint laboratory at Bentonville, Ark., for the study of apple and other insects and diseases in that region. This work is meeting with the hearty cooperation of the orchardists. Other experiments are in progress in southwestern Missouri and in Arkansas, with Bentonville as headquarters.

Orchard spraying work is also being carried on, in cooperation with the New Mexico Agricultural Experiment Station, in the Pecos Valley, N. Mex. Here the effort is directed toward determining the comparative merits of different numbers of spray applications

and at different times under semiarid conditions. At four localities in the valley portions of orchards have been taken over by the department under cooperative arrangements with growers.

At all of these stations experiments to determine the comparative merits of dusting and liquid sprays are in progress. This side of the work has been especially keen at Winchester, Va., where it has been shown that, with certain varieties such as the York Imperial, which is little subject to apple-scab, dusting will be an effective substitute for spraying.

OTHER APPLE INSECTS.—Especial attention has been given during the year to the plant-lice occurring upon apple, and particularly to a certain group in which much confusion exists regarding the identity of species and the alternate host plants, this confusion standing in the way of remedial and preventive work. Valuable results have been reached.

The work which has been carried out on the apple-tree borers and other fruit-tree borers has been continued and will be brought largely to a conclusion this year. Studies have also been made of the apple curculio, the giant root-borer, various leafhoppers, the imbricated snout-beetle, the apple maggot, and others.

GRAPE INSECTS.

GRAPE-BERRY MOTH.—In northern Ohio the grape-berry moth work has been continued and materially enlarged. During the year especial attention has been given to the perfecting of a spray schedule and to the making of improvements in methods of application of sprays. There is some ground for belief that a single timely and thorough spraying will be sufficient, and if so this will do away with the objectionable spray residue on the fruit at harvest time. Dusting experiments also are being carried on in connection with this investigation, arsenate of lime being compared with arsenate of lead.

OTHER GRAPE INSECTS.—The so-called grape mealybug has become troublesome in parts of California, where its life history has been studied to practical completion, and a large amount of experimental work with sprays and other remedial measures has been carried on. This is a difficult insect to handle, since it secretes itself under shreds of bark where sprays can not reach it readily. The work on the grape phylloxera has been continued on a reduced scale, the effort being to determine the best means of disinfection of rooted vines and cuttings tied in bundles according to the usual nursery practice. A thorough survey of Fresno County, Cal., which has been carried on in cooperation with the Bureau of Soils, to determine the relation of soil conditions to severity of phylloxera attack, has been practically completed.

PECAN INSECTS.

Additional information has been gained regarding the life histories of important insect enemies to pecan, and especial attention has been given to the use of insecticides in orchards or groves in southern Georgia and Florida. Growers have actively cooperated. Work of this kind has also been carried on in southern Mississippi and in the vicinity of Brownwood, Tex.

INSECTICIDE INVESTIGATIONS.

Work under this project has been continued as in former years in cooperation with the Bureaus of Plant Industry and Chemistry, and has included the testing of miscellaneous proprietary insecticides, and further testing of insecticides developed by the bureau or others for use alone and in combination with fungicides. Further attention has been given to the determination of the range of usefulness of calcium arsenate on pome and stone fruits and grapes. Testing work is under way in Connecticut, Michigan, Virginia, Arkansas, New Mexico, Colorado, and Oregon. Working under these varied climatic and other conditions, the results, when available, should settle the points under investigation.

In view of the present high cost of arsenate of lead, orchardists and manufacturers have evidenced decided interest in arsenate of lime. Experiments thus far made indicate that it may be used in all situations where Paris green has been employed, and that for pome fruits it will be a satisfactory substitute for arsenate of lead when used with lime or fungicides containing lime.

Progress has been made in the investigation of the insecticidal constituents of plants, especially the so-called derris. This insecticide of oriental origin acts both as a contact and as a stomach poison. As a stomach poison it is efficient against only a few insects, while as a contact insecticide it is efficient against a wide range of insects. A detailed report on the subject is planned at the close of the growing season 1918.

Further tests have been made with nicotine as an agent for killing the eggs of insects, especially those of the codling moth. Results as a whole indicate an ovicidal action of nicotine, but not sufficient to give satisfactory control of the codling moth when used alone. Preparation of a report on the subject will be undertaken as soon as data for the present season's work are in hand.

Studies of the relative toxicity and physical characteristics of various arsenicals, undertaken in cooperation with the Bureau of Chemistry, are being continued and progress made. An extended report on insecticides, spraying apparatus, etc., has been issued as Farmers' Bulletin 908.

CRANBERRY INSECT INVESTIGATIONS.

The work on cranberry insects in New Jersey has been completed, and a Farmers' Bulletin (No. 860) covering the principal insect pests of this crop in that State has been published. Special articles on the more important species have been published or are in the course of preparation, and practical control measures have been developed for the principal pests.

An investigation of the insects affecting cranberry bogs in the State of Washington has been undertaken in cooperation with the agricultural experiment station of that State, beginning with the spring of 1918. Several of the important eastern cranberry-insect pests have been introduced into the Washington bogs with plants from the East with which the bogs were started, but it will be necessary not only to study these insects under their new far-western conditions but also to see whether native western insects will take to the

cranberry out there. It has already been shown that the methods of control of the blackhead fireworm effective in the East are also effective against this insect under the conditions in the State of Washington.

PEACH INSECTS.

Additional information on the use of fumigants in the control of the peach borer has been obtained. It now appears probable that by the proper use of para-dichlorobenzene, applied in small doses around the base of trees during the fall of the year, this pest may be controlled at a minimum cost; but further tests under a variety of conditions are under way. Positive recommendations probably will be made at the end of the present growing season.

On account of the interest aroused in the dusting of apple orchards, peach growers desire to know whether this method of insect and disease control is applicable to peach orchards. Therefore, in cooperation with the Bureau of Plant Industry, experiments have been carried on at Fort Valley, Ga., concerning the value of arsenate of lead and sulphur dust in the control not only of the plum curculio but of peach-scab and brown-rot. Similar experiments are in progress in Arkansas and at points in West Virginia, Maryland, and Michigan. Results are not yet available, but it is hoped that positive recommendations can be made before next year's spraying season.

The so-called oriental peach moth, mentioned in the last report as a newly established peach pest from Japan, has received particular attention. It has been found to attack not only peaches but apples, pears, quinces, plums, and cherries, and bids fair to be a serious pest. The present distribution of the insect is under investigation, and the facts will soon be placed at the disposal of State entomologists and others concerned with nursery and fruit quarantines. Posters showing the injury done by this insect have been widely distributed.

Much complaint has recently been received from Oregon of damage by the so-called California peach-borer. It appears that this insect at present is unusually destructive to prunes. An investigation has been begun.

NATURAL CONTROL OF DECIDUOUS-FRUIT INSECTS.

Investigations of the parasites of the grape-berry moth, under way for several years at North East, Pa., have been completed, and much additional knowledge has been gained. About 50 species of parasites of this insect have been found, only 7 or 8, however, of sufficient numerical importance to be at all effective. In the same way the insect parasites of other deciduous-fruit pests have been studied. Study of the fungous diseases of these pests and other insects has also been continued under this section of the bureau's work. This is a very promising line of investigation and encouraging results have been obtained. A new disease attacking the citrus mealybug of Louisiana has been discovered.

Similar work on the value of predatory insects in deciduous-fruit insect control has been carried on, partly in cooperation with the California State Horticultural Commission, since the need of more exact information in this direction has become very evident.

THE JAPANESE BEETLE (*POPILLIA JAPONICA*).

The recent introduction in the vicinity of Riverton, N. J., of the Japanese beetle (*Popillia japonica*), a serious insect pest in Japan, has resulted in an investigation of the insect by the Bureau of Entomology and an attempt at its eradication in cooperation with the New Jersey State entomologist. A laboratory for biological and other studies has been established at Riverton, and this place has been made headquarters for the eradication work.

It appears that the beetle was brought into this country in shipments of Japanese iris during the summer of 1911, probably in the egg or larva stage in the soil about the rhizomes of the iris plants. Some 625 acres are now heavily infested with the beetle, and it is scatteringly found over some 7,000 to 10,000 acres, with outlying infestations over not less than 25,000 acres.

The insect has been found to be a very general feeder, attacking grape, apple, cherry, buckwheat, sweet potato, corn, and many ornamentals and weeds, as smartweed, morning glory, black locust, ironweed, etc. It has been recorded from a total of 41 plants.

The immature stages are passed in the soil, where the larvæ feed on decaying vegetable matter. The adults appear by midsummer, continuing until cool weather in fall. During hot days the beetles are strong fliers, which adds much to the danger of their spread. The insects attack the ends of ears of sweet corn, and in the movement of green corn to market can be scattered to various parts.

In the work of eradication several lines are followed, as the treatment of infested soil with sodium cyanid solution, the destruction of breeding grounds by plowing, and keeping the insects away from roadsides by the use of kerosene oil and other means. Direct measures against the beetles are taken by applying poisons as nearly as possible to the entire infested area, working from the periphery of the area inward. A large amount of hand picking is also being done and great quantities of the beetles have already been collected and destroyed.

CEREAL AND FORAGE INSECT INVESTIGATIONS.

Mr. W. R. Walton has continued in charge of this important section of the work of the bureau.

EUROPEAN CORN BORER.—Doubtless the most important development of the year with respect to insects affecting cereal crops was the discovery, late in the summer of 1917, that a very serious European pest of Indian corn had become established in eastern Massachusetts. This lepidopterous insect (*Pyrausta nubilalis*) is well known in Europe and Asia, where it occurs in injurious abundance throughout central and southern Europe and west central and northern Asia and Japan.

Among the cultivated crops attacked in these countries are corn, hemp, hops, millet, several wild grasses, and many common weeds. In this country corn is the principal cultivated crop seriously injured, but the damage to that crop is so serious as to cause the gravest apprehensions should this insect spread into the great corn belt of the Middle West. The caterpillars, of which there are at least two generations annually, bore into the stalk, ear, and tassel of the plant.

Thirty or more individuals often are to be found in one stalk during the latter part of the summer.

Vigorous action has been taken looking toward the control of this pest, and a cooperative investigation was initiated by State and Federal entomologists in order to determine the most effective means of dealing with it. At present the area known to be infested amounts to something more than 300 square miles. The Massachusetts State Agricultural College, State Board of Agriculture, and Foresters' Association, together with the members of the gipsy-moth investigational staff, are cooperating with the Branch of Cereal and Forage Insect Investigations of the bureau in keeping the insect under surveillance. Fortunately the insect passes the winter in the stalks of its host plants, and winter destruction is therefore possible, although extermination throughout its present range, on account of its numerous food plants, would be a matter of great difficulty and expense.

ALFALFA WEEVIL.—During the summer of 1917 the alfalfa weevil was discovered to have extended its range southeastwardly into the State of Colorado. The infested area, amounting to about 3 square miles, was located near Paonia, Delta County. Cooperative investigational and control work was at once organized by the State and Federal entomologists, and this outbreak is now receiving the most approved treatment. In Utah, southeastern Idaho, and southwestern Wyoming, where the insect has been present for some years and where control measures have been practiced for a considerable period of time, satisfactory conditions prevail. The natural enemies of the weevil, introduced from Europe in large numbers, have greatly increased in abundance and apparently are giving material aid in controlling the pest.

CHINCH BUG.—No general outbreak of the chinch bug has occurred during the year, although considerable damage throughout northern Texas occurred during the season of 1917. Surveys conducted throughout the winter in eastern and northern Texas indicated great danger of a continuation of the injury on a larger scale during the early summer of 1918, and an educational campaign was conducted in order to induce the farmers of Texas to begin to combat the insect early in the season. This movement was supported admirably and doubtless resulted in much good. The outbreak was further subdued by very heavy rains which occurred during the spring of the current year.

GRASSHOPPERS.—The summer of 1917 was remarkable for the severe and widespread injury by grasshoppers to forage crops throughout the Western and Northwestern States. The injury mentioned in last year's report was continued until the close of the growing season of 1917, and, owing to the unfavorable outlook, State and bureau forces were organized in North and South Dakota, Montana, Oregon, Washington, Colorado, Kansas, and Nebraska for the purpose of fighting the coming outbreaks of 1918. This cooperative movement undoubtedly has resulted in greatly reducing the losses which otherwise would have resulted. At present the indications point to a much less severe loss than occurred during the summer of 1917.

HESSIAN FLY.—The Hessian fly situation has continued to improve throughout the year. In eastern Kansas, where danger threatened during the fall of 1917, a cooperative campaign to secure the plowing down of stubble and the general observation of the safe planting date is believed to have been responsible, at least in part, for the greatly improved conditions which prevailed during the spring and summer of 1918. In Illinois, Indiana, and Missouri, where full advantage of the safe planting period was taken by growers, the current crops of winter wheat were excellent. Work on the experimental plats was continued and intensified during the year. Many new instruments were installed and two additional plats have been located, one at Forest Grove, Oreg., and the other near Carlisle, Pa. Investigations in the western half of the Mississippi River Basin have been reorganized and improved. The results obtained from the experimental plats have enabled the bureau to forecast Hessian fly conditions and thus to issue timely and valuable information.

CUTWORMS.—Several outbreaks of cutworms occurred during the summer months of 1917 in some of the Middle Western and Southwestern States. A notable outbreak of the granulated cutworm occurred in one of the irrigated sections of southern Arizona, where alfalfa is the staple forage crop. This outbreak was successfully treated by means of the poisoned baits. Experimental work with sawdust as a substitute for bran in such baits demonstrated the practicability of cheapening the mixture by the use of sawdust.

JOINTWORM.—Jointworm injury to wheat was unusually severe in the States of Michigan, Indiana, Tennessee, Virginia, and portions of Illinois during the year. The work of this insect doubtless was responsible for a considerably decreased yield of grain in these States. A new Farmers' Bulletin (No. 1006), giving advice for the control of the jointworm, is in process of publication. In Michigan, where injury has been general, the planting of rye instead of wheat is advised, because the former grain is not subject to wheat jointworm attack and gives a more satisfactory yield than wheat in that State.

COULEE CRICKET.—For several years past the Coulee cricket (*Peranabrus scabricollis*) has been responsible for progressively serious injury to crops in Grant County, Wash., and considerable sums of money have been expended by the State and county authorities in fighting it. During the spring of 1918 the bureau was enabled to provide an entomologist who could devote his entire time to the control of this pest, and as a result of his efforts, in cooperation with the investigational staff of the bureau, complete control was secured. Judging by present appearances little injury from this insect is likely to occur for some time to come. In case of a subsequent outbreak the methods originated and applied this year doubtless will prevent serious injury in the future.

SAWFLY INJURY TO WHEAT.—In July, 1918, an outbreak of a wheat-infesting sawfly occurred near Gaithersburg, Md., where it was responsible for rather serious injury to winter wheat. A preliminary survey subsequently conducted discovered the insect in northern Virginia and throughout most of Pennsylvania and Maryland. In appearance and methods of injury the insect resembled the wheat-stem sawfly, which at present is responsible for considerable injury to spring wheat in North Dakota and contiguous territory.

The insect responsible for the injury in the Eastern States above mentioned has been identified as *Trachelus tabidus*, a European sawfly. This insect is known to have been present in Pennsylvania since 1913, but appreciable injury to wheat has not been observed until very recently. Possibly the rapid multiplication of the insect has been aided by the recent movement for an increased production of wheat and the consequent planting of wheat for two or more years in succession on the same land. As is the case with the Hessian fly and the jointworm, this sawfly hibernates throughout the winter in the wheat stubble of the current year. An investigation of this insect has been started.

STORED-PRODUCT INSECT INVESTIGATIONS.

This section of the work of the bureau has been carried on during the fiscal year under the immediate charge of Dr. E. A. Back.

Because of the general needs of this country and of allied countries in the present crisis, the efforts of this section have been directed almost entirely toward the dissemination of information regarding the suppression of insects affecting stored food supplies, particularly the insect pests of beans, peas, corn, wheat flour, and food products made therefrom. Experts on the Pacific coast and in the South have been engaged in the inspection of many warehouses and mills where food supplies are stored.

Throughout the year large supplies of food that were being seriously affected by insects have been located. The owners of such supplies have been advised regarding the necessity for prompt action in order to avoid further losses, and have been shown how to prevent losses to newly acquired supplies that are free from insects. This service has been extended to farmers, particularly growers of corn and rice, whose crops suffer extensively through weevil attack.

Arrangements have been made with the Quartermaster Department of the Army at the port of New York whereby the bureau undertakes to make frequent inspections of food and clothing supplies intended for overseas shipment. The purpose of this cooperation is to keep the Quartermaster Department informed, through inspections made by experts, not only of the condition of food supplies purchased and delivered at the warehouses but also of their condition from time to time during the storage period. Such inspections detect and lead to the checking of insect ravages before the insects have had the chance to multiply and cause great losses. Much good has already resulted from this work, and as the warm weather continues the loss through insect attack will be greatly lessened.

INVESTIGATIONS OF INSECTS INJURIOUS TO VEGETABLE AND TRUCK CROPS.

The work on this group of injurious insects has been continued, as in former years, under the direction of Dr. F. H. Chittenden. The more important subjects of research have been insects injurious to potato, tomato, and related plants, to beans and peas, to sugar beets, and to sweet potato, especial attention having been given, under an emergency appropriation, to the study of the sweet-potato weevil in its occurrence in the Gulf States, with the object of control and eradication.

SWEET-POTATO WEEVIL ERADICATION AND CONTROL.

Following an urgent request, an emergency fund of \$30,000 was made available about March 1 for an investigation of the sweet-potato weevil in the States of Florida, Georgia, Alabama, Mississippi, Louisiana, and Texas, which might lead to its eradication and control. This has made possible a preliminary farm-to-farm survey of all outlying infested territory, definitely establishing the boundaries of infestation. A series of large-scale experiments in control have been undertaken at field stations in Texas, Mississippi, and Florida, and demonstration eradication projects have been initiated in portions of Florida, Georgia, Mississippi, and Alabama, the close survey accomplished having established the feasibility of operations for that purpose.

An educational campaign by inspectors has already been productive of much benefit and has reduced materially the number of infested farms in Georgia, Alabama, and Mississippi; indeed, it seems probable that the completion of another season's work may find the sweet-potato crop of the least infested of these States nearly weevil free.

Experiments with heat curing of sweet potatoes have shown the possibility of securing a mortality of 95 per cent of weevils in storage houses by carrying the tubers at a temperature of 115° F. for eight days. In badly infested districts in Texas, where weevil injury is frequently 50 per cent, losses have been reduced to less than 10 per cent by the timely application of arsenical sprays.

Life-history investigations have brought forward many interesting facts regarding this weevil which can be applied the coming season to excellent advantage. Good progress has been made in a survey of the wild food plants of the pest. On the whole, the beginning of the fiscal year 1919 finds the bureau well equipped to conduct a most effective campaign against this pest during the coming season.

OTHER INSECTS OF POTATO, TOMATO, AND ALLIED PLANTS.

The potato aphid, which was an unexpected pest in 1917, reappeared in still greater numbers in many regions in the early summer of 1918. It attacked both tomato and potato, and occurred along the Atlantic coast from Maryland and Virginia to New England and to a lesser extent westward to Ohio, Indiana, Illinois, Michigan, and Wisconsin. In Maryland it was controlled by nicotine sulphate used at double the strength generally advised for plant-lice. This doubling was necessitated by the greater resistance of the pest and by the unwillingness of the farmers to make a second spraying, on account of the scarcity of labor and appropriate spraying machinery. A still larger dosage, namely, one-half pint of nicotine sulphate to 50 gallons of water, was found desirable in New Jersey and Massachusetts.

The spinach aphid caused considerable loss to potato, tomato, cabbage, turnip, radish, beets, lettuce, and other truck crops. It covered practically the same territory and succumbed to the same remedies.

The potato flea-beetle, the three-lined potato beetle, and the potato fruitworm, as well as the common stalk-borer, were numerous and received careful consideration.

INSECTS AFFECTING GROWING BEANS AND PEAS.

An investigation of the bean ladybird—an insect which is to the bean crop of Colorado, New Mexico, and neighboring States what the Colorado potato beetle was to the potato crop in earlier years—was undertaken, and the results are available for publication. Additional experiments, however, are necessary for the control of this insect in order to lessen damage to the crop by the means of control themselves.

The pea aphid has been studied in California, as well as a pea moth which has been introduced during the year into Wisconsin, and two species of borers which affect especially Lima beans, one in the Southern States and the other in the Pacific region. Enormous areas in Lima beans and other beans were planted this year in southern California, and there has been a severe and unusual outbreak of the corn earworm upon the bean pods in that part of the country, necessitating careful studies of the conditions which have brought about the damage in the hope of preventing it another year.

OTHER TRUCK-CROP INSECTS.

The problem of the control of the onion thrips has been solved, and the department is now able to prescribe practically new methods of treatment which give excellent results. Some progress has been made in the control of the onion maggot by the use of sweetened sodium arsenate and arsenite in the destruction of the adult flies while depositing their eggs.

In the same way insects injurious to crucifers, such as the cabbage aphid, the false turnip aphid, and the harlequin cabbage bug, have been studied. The last-named pest, ordinarily an important one throughout the South, was largely controlled by the cold winter of 1918.

Work on insects injurious to strawberry, blackberry, raspberry, and related plants of the rose family has been continued in several States, and good results have been accomplished in the line of control of the leaf-rollers by arsenical spraying. A saving of at least 50 per cent was made in experiments in Iowa, and in Kansas a single spraying resulted in destroying two-thirds of the pests.

Investigations of insects as agents in the transmission and overwintering of the disease of cucurbit vegetables known as "mosaic" have been continued in Indiana and Wisconsin. Hundreds of individual insects were used in hibernation experiments, and about 100 experiments in control by insecticides are now under way.

The principal investigations of the insects affecting sugar beets have led toward the solution of the problem presented by the annual damage from the curly-top disease. It has been shown that a leaf-hopper is the agent responsible for the transmission of this disease, and studies of the life history and economy of the insect carrier have been nearly completed. These have led to experiments in the time of planting which have yielded results of such value that their application to commercial plantings will probably insure a paying crop in infested regions.

SOUTHERN FIELD-CROP INSECT INVESTIGATIONS.

Dr. W. D. Hunter has been in charge of these investigations, as formerly.

COTTON-BOLL WEEVIL KILLED BY POISON.—One of the most striking achievements of the bureau culminated during the year in the announcement of the value of powdered lead arsenate or calcium arsenate against the cotton-boll weevil. After years of experimentation the bureau is now able to announce that the weevil can be killed during the summer months by dusting the cotton with either of these poisons at the rate of 5 pounds per acre, with three to five applications at weekly intervals. The poisoning, to be most effective, should be done between 4 p. m. and 9 a. m., and the powder should be applied by means of a rotary dust gun or by power machinery. A special power machine has been developed which will cover nearly 200 acres per day. The cost of treatment is about \$1 per acre for one application. Distinct gains in yield of from 250 to 1,000 pounds of seed cotton have been obtained. It is hoped that the application of this discovery will greatly increase the yield per acre of cotton, one of the most important crops of the Nation.

OTHER COTTON INSECTS.—Other work on cotton insects, as indicated in the last annual report, has been carried on at Tallulah, La., Madison, Fla., and El Centro, Cal., the recent developments of cotton in the last locality, in the Imperial Valley, necessitating careful watch for cotton pests.

Research work on the pink bollworm of cotton in the Laguna district of Mexico has been carried on by experts of the bureau detailed to the Federal Horticultural Board, and will be mentioned in the report of the board.

OTHER SOUTHERN FIELD-CROP INSECTS.—On account of the extension of sugar-cane culture in southwestern Texas, a laboratory has been opened at Brownsville for the investigation of sugar-cane insects.

The investigations on tobacco insects, mentioned in the last report, have been continued.

The demands of the War Department for great quantities of castor oil led to very extensive planting of castor beans under contract in various southern States. Early in the season complaints began to come in of insect injury to these plantations, and the bureau has given especial attention to the control of these pests.

INSECTS AFFECTING THE HEALTH OF MAN AND ANIMALS.

With the beginning of the war, very elaborate tabulations and card indexes of the relationships of insects to the health of man and animals were prepared. This information has been placed at the service of the War Department and has enabled the bureau to give prompt service in many emergency cases. A close contact has been maintained with the sanitary officers, so that the bureau has been able to render service in the solution of certain camp problems.

Acting in cooperation with the National Research Council and the War Department, a study of the body louse was taken up and in-

vestigations have been made of all remedies proposed against the louse. Especial researches have also been undertaken in the search for new lines of treatment. Results of all tests are immediately communicated to the office of the Surgeon General of the War Department.

The chief of the bureau has been made chairman of the subsection of medical entomology of the National Research Council, and in this way all questions that arise are officially handled.

The work on insects affecting domestic animals, as outlined in the last annual report, has been continued. The insects frequenting packing houses and abattoirs have been under observation. Traps of different kinds have been experimented with, and the other lines of work indicated in the last annual report have been followed up.

INVESTIGATIONS OF INSECTS AFFECTING FOREST RESOURCES.

The work of the branch of Forest Insects, under the supervision of Dr. A. D. Hopkins, has been concentrated during the year on subjects which have a direct or indirect bearing on war-time needs.

Early in the year a conference was held with representatives of the branches of the War and Navy Departments, Shipping Board, etc., who are responsible for the supplies drawn from the forest resources of the country. The object of this conference was to offer the services of the bureau and explain how it could help through special investigations and advice toward preventing serious losses of forest resources from damage by wood and bark boring insects.

Recent investigations of logging and manufacturing operations in Mississippi to meet the demand for ash oars, handles, and other supplies, required by the war service, showed that one company had lost more than 1,000,000 feet of ash logs through failure to provide for prompt utilization after the trees were cut and thus prevent the attack of the destructive ash-wood borers.

There is a continued reduction of the heretofore serious losses of seasoned ash and other hardwood sap material from powder post, due to the more general adoption of the methods advised by the bureau. This has been accomplished largely through the adoption of methods of management by the manufacturers and shippers with little or no additional cost.

By far the most extensive insect-control reconnaissance that has been carried out to date is the "California survey," which was completed during the year. This was organized as a cooperative project in which a number of California lumber companies, the Forest Service, and the Bureau of Entomology were engaged. The general supervision of the survey was assigned to the assistant forest entomologist, Mr. J. M. Miller, who has charge of the Pacific slope field station.

The territory covered consisted of the pine belt along the western flank of the Sierra Nevada Mountains between the American and Kern Rivers. The results of this survey showed that the loss in 1917 from tree-killing beetles on the 1,682,000 acres covered was approximately 27,000,000 feet of merchantable timber with a stumpage value of \$60,000. If the recommendations of this bureau are adopted by the Forest Service and private owners and properly carried out, it is certain that a large percentage of this annual loss can be prevented,

and that through the application of the percentage principle of control it is entirely practicable to do so at a comparatively small cost.

In the Southwest, where the mesquite furnishes the only local supply of fuel, fence posts, etc., serious losses are suffered each year from wood-boring insects. Large quantities of mesquite are used for fuel at the Army cantonments, rendering the problem of especial interest in this connection. In order to determine a method of conserving the resources supplied by the mesquite, a special field station was established near Tucson, Ariz., at which mesquite has been cut every two weeks since October, 1917. The results of this experiment so far have been most gratifying in showing that mesquite cut in November and December and piled in loose ricks is comparatively free from damage, while that cut during the other months is seriously affected and in some cases its value is entirely destroyed.

The black locust has come into prominence on account of its value in supplying the best pins used in the construction of wooden ships. Heretofore it has not been practicable to grow this tree commercially on account of the damage to the tree and wood by the locust borer, but recent experiments have shown conclusively that it can be protected from the borer by spraying the young trees with a poisoned liquid and by a more practical method of providing a dense shade in the plantations by the use of some quick-growing shade-producing plant between the rows.

In connection with the pressing need of an increased food supply, Dr. Hopkins volunteered his services for the investigation of periodical farm practice with special reference to the application of his bioclimatic law of latitude, longitude, and altitude as a guide to the best time and period each season to do the work. This law, which has been worked out in its relation to research and practice in entomology, was believed by him, as suggested in the report of the Entomologist for the fiscal year 1917, to be equally applicable to research and practice in agriculture. Therefore much of his time during the year was devoted to a study of the application of the law to the predetermination of the safest and best time to sow winter wheat at any place in the United States where the conditions are favorable for its profitable growth.

The results of the investigations as set forth in his paper, "Periodical Events and Natural Law as Guides to Agricultural Research and Practice," published as Supplement 9 of the Monthly Weather Review, seem to have proven the practicability of the application and to have introduced a new line of attack for all problems relating to periodical farm practice, and seem to have a promise of ultimate results of special value toward increasing the food supply and the general advancement of agriculture.

TROPICAL AND SUBTROPICAL FRUIT INSECT INVESTIGATIONS.

This branch of the bureau's investigations is under the charge of the assistant chief of the bureau, Mr. C. L. Marlatt.

INVESTIGATIONS OF INSECTS AFFECTING CITRUS FRUITS IN CALIFORNIA.—Work in control of the two important mealybug enemies of citrus trees has been continued during the year and has resulted in notable success. The means now recommended by the department are

being generally recognized as practicable and efficient methods of handling infested orchards. This is particularly true in reference to the so-called citrophilus mealybug. The study of this insect was begun during the year in response to a petition from citrus associations and fruit exchanges in western San Bernardino County, where considerable alarm had been aroused by the rapid spread and great damage done by this scale insect. The citrophilus mealybug is a comparatively new pest, which started with an invasion of a few trees in 1915, but now covers an area of about 1,000 acres. A 20-acre demonstration plot has been freed from this mealybug by the combined procedure of control of the Argentine ant, spraying the trunks of the trees, and utilization of predatory natural enemies.

The important relationship of the Argentine ant to infestation by mealybugs in southern California has necessitated as a first step the control of this ant. This is accomplished by the use of poisoned ant sirup. This method of control has already been extended to upwards of 200 acres in this district, and a great expansion of this work is now in progress.

The hydrocyanic-acid gas investigations in southern California have been continued more particularly with relation to the use of liquid hydrocyanic acid—a method which on account of its convenience and efficiency bids fair to supplant the older methods of generating gas by a combination of the necessary chemicals at the moment of use. The most economical method of production of this liquefied gas is being worked out, together with field experiments to determine the best methods of use and to eliminate the risk of accidental poisoning of workmen. A Farmers' Bulletin (No. 923) has been issued, bringing down to date the standard method of fumigation hitherto used and giving full instructions for such fumigation.

CITRUS-FRUIT INSECTS IN FLORIDA.—The work of this department in the control of citrus insects has taken the form in Florida of regional orchard demonstration and is coordinated with the extension work in this State. During the year two bulletins in relation to this work have been published. One (Department Bulletin 645) is entitled "Some Reasons for Spraying to Control Insect and Mite Enemies of Citrus Trees in Florida," and the other is a Farmers' Bulletin (No. 933) giving specific directions for spraying for the control of such insects.

CONTROL OF THE FLUTED SCALE IN NEW ORLEANS.—This project was completed during the year and was discontinued June 30. It was an enterprise conducted by the city of New Orleans, the State of Louisiana, and this department in cooperation. The control of the fluted scale has been accomplished in New Orleans and neighboring places by the propagation and liberation of thousands of the natural enemy of this scale insect, the Australian ladybird, *Novius cardinalis*. Over 300 colonies of these ladybirds were liberated over an area of 40 square miles. The distribution of this beneficial ladybird has been extended to the known outlying infestations of the fluted scale in Louisiana, Mississippi, and Texas. In connection with this work some very interesting studies have been made of the fluted scale, its ladybird enemy, and particularly the symbiotic relationship between the fluted scale and the Argentine ant. The results of this work demonstrated that this ant by protecting the fluted scale from its

natural enemies enormously increased the multiplication and destructiveness of this scale insect, and that therefore one of the effective means of controlling this scale is to control the ant, as has been demonstrated similarly in the case of the mealybug in California, referred to above.

STUDIES OF GREENHOUSE INSECTS.—The spreading and penetration qualities of various contact insecticides employed in the control of insects occurring in greenhouses, with especial reference to the effect of these solutions on the plants, if applied to the soil for subterranean pests, have been under study and a considerable amount of data relative thereto assembled. The life history of the chrysanthemum aphid has been worked out and the value of water under pressure as a means of controlling the red spider determined. Several manuscripts dealing with important injurious greenhouse insects are in the course of preparation.

MEDITERRANEAN FRUIT FLY AND MELON FLY.—Under the Mediterranean fruit fly and melon fly quarantine the following fruits and vegetables are inspected and certified as a condition of their shipment from Hawaii to the mainland of the United States: Bananas of the noncooking type, pineapples, taro, and coconuts. Provision is also made for the certification for movement to the mainland of other fruits and vegetables when it can be shown to the satisfaction of the Department of Agriculture that such fruits and vegetables in the form and manner in which they will be shipped are not and can not be a means of conveying either the Mediterranean fruit fly or the melon fly. This work is a continuing work, except as to changes which may be made from time to time in the list of fruits the export of which is permitted under the direction and supervision of the Federal Horticultural Board in cooperation with this bureau.

The studies of introduced parasites have been continued during the year, and a number of very important biological facts have been determined which have added much to the knowledge of the problem of control of fruit flies by these introduced parasites, and have wide bearing on the subject of parasitic control of injurious insects. A number of technical papers on this subject have been published during the year. Notably in the case of coffee and to a certain extent also in the case of edible tropical fruits, the work of the fruit fly has been very materially checked by these introduced parasites.

EXTENSION AND DEMONSTRATION WORK.

By act of Congress, under provisions of the food-production act to stimulate agricultural production, funds were made available for this bureau to disseminate information, by demonstration or otherwise, as to methods of preventing the loss due to insects and for increasing the production of honey. This work has been placed under the supervision of Mr. J. A. Hyslop and has been carried on in cooperation with the States Relations Service and with the State agricultural colleges and experiment stations. Special field agents in entomology have been appointed and are reinforcing the State entomological forces and assisting the county agents in the several States.

This work is being carried on in the various States under definite project agreements. These projects have been formally accepted by 33 States and are in accordance with the general memorandum of understanding in force between these States and the United States Department of Agriculture.

An average of 57 specialists from the Bureau of Entomology has been maintained in the field, these men being selected with a view to their training, experience, and knowledge of field conditions in the regions in which they are to serve. Their work consists essentially in carrying out campaigns in the extension of knowledge of the methods of fighting insects, covering as effectively as possible all the important crops and domestic animals. These specialists give demonstrations to groups of farmers, live-stock men, fruit growers, and others in the preparation of spray mixtures, emulsions, and poisoned baits, and in other methods of insect control. Wherever it is possible, persons in the communities where demonstrations are being made are induced to assist in the work in order that each community may have one or more persons acquainted with the methods of assembling and applying insecticides.

Seventeen special field agents have been employed to carry on extension work in the control of insects affecting cereal and forage crops. The outstanding feature of this work has been an extensive and successful campaign for the control of grasshoppers, which early in the season promised to be extremely destructive in the upper Mississippi Valley and in Montana. The first successful campaign for the control of the "coulee cricket" in the Pacific Northwest was carried on by two of these agents in Washington and Oregon this summer. During last fall a very successful campaign for the control of the Hessian fly was carried on in the middle western wheat region, and considerable effort was directed this spring to the control of the European corn borer, a newly introduced corn pest in New England.

Three special field agents and two entomological assistants are carrying on extension work in the control of stored-product insects. The work is being confined to the Gulf States and Georgia, with the exception of the work being carried on in connection with the Quartermaster's Office for the port of New York. The work in the Southern States has been almost exclusively in the control of the black corn weevil, a pest which is conservatively estimated as annually destroying 10 per cent of the stored corn in the cotton belt. The work with the Quartermaster's Department in the port of New York has been on the control of insects which destroy both food materials and supplies held for over-seas shipment.

Twelve special field agents are carrying on extension work in the control of truck-crop insects. Owing to the nature of this work it has been found necessary to depart from the regional standpoint and place an agent more or less permanently in each State in which work is undertaken, as these agents find it necessary to correlate their work very closely with that of the county agent and the work becomes more effective the longer the field agent remains in any given State. This work last year was carried on in South Carolina, North Carolina, Louisiana, Maryland, Texas, Connecticut, New York, Massachusetts, Maine, Wisconsin, California, and Washington. The work in

the Atlantic Coast States was extremely effective in controlling a very serious outbreak of the potato aphid.

Nine special field agents are engaged in extension work in the control of deciduous-fruit insects, one agent being located in each of the following States: Washington, Oregon, Texas, Indiana, Kansas, Mississippi, Virginia, Rhode Island, and North Carolina. These agents have closely associated their work with that of the county agents, putting on demonstrations, assisting in sprayings, advising fruit growers, and giving lectures. In addition to this work, eight entomological inspectors have been employed in survey work to determine the territory covered by the recently introduced oriental peach moth.

Three agents in California and one in Florida are carrying on extension work in the control of citrus-fruit insects. The work in California has been very largely devoted to teaching methods of destruction of the Argentine ant, which incidentally will control certain of the mealybugs attacking citrus fruits.

Three agents are covering the entire lower Mississippi Valley, teaching methods of control of insects affecting poultry and cattle.

An average of six special field agents has been maintained in the field teaching modern methods in beekeeping. Work has been carried on in 34 States along this line, and the field agents have addressed nearly 25,000 beekeepers and have visited 1,198 apiaries to give personal instructions. In addition to this they have organized 84 county beekeepers' associations in the several States.

In all, the bureau's agents have held 338 conferences with county agents, extension directors, State entomologists, and others to further this work; they have put on 894 demonstrations where practical methods of insect control were actually used before growers and livestock men; they have visited 5,823 farmers to give personal advice on entomological questions, and have delivered 1,366 lectures before audiences amounting to 90,385 persons.

The bureau's representative in this work is cooperating with the States Relations Service by making an annual inspection of all States carrying on Smith-Lever fund work in entomology, with a view of improving and correlating the efforts in entomological extension work.

Another activity of this office has been the work in connection with the Bureau of Entomology's exhibits. This year an exhibit consisting of 10 screens, one screen to illustrate the activities of each of the bureau's research offices, has been prepared. These screens each contain eight bromide enlargements of the important pests, their ravages, and the methods for their control. This exhibit is part of the large interdepartmental exhibit which was displayed at 32 of the State fairs throughout the country. The motion-picture activities of the bureau have been arranged for in connection with the work on exhibits, and several films have been prepared.

WAR EMERGENCY ENTOMOLOGICAL INTELLIGENCE SERVICE.

Cooperative arrangements have been made with the entomologists of the various agricultural colleges and experiment stations, with the teachers of entomology in the other colleges and universities, with the field workers of the Forest Service, with the county agents

in the different States, with field employees of the extension service, and all other available observers, by which undue increase of any insect pest is immediately reported to this bureau, in order that knowledge of prospective outbreaks should be first centralized and then distributed to bring about the promptest and most efficacious measures. In this way the almost daily condition of the principal crops of the country in regard to injurious insects is thoroughly well known for the entire country. This information has been brought together and issued to the economic entomologists of the country in the form of manifold emergency circulars published at the end of each month. While it is impossible to estimate in any way the value of this service, there can be no doubt that it is well worth while and that it has been of a very considerable monetary value.

BEE-CULTURE INVESTIGATIONS.

This work has continued under the supervision of Dr. E. F. Phillips.

The export demand for honey has increased greatly since the beginning of the European war, indicating that honey has ceased to be a luxury in the minds of the allied peoples. During the last half of the year honey was exported to the value of perhaps \$2,000,000, about ten times the valuation of the export of honey for any year before the beginning of the war. The home demand for honey has also increased, but it is difficult to give any figures for this, as much of the honey of the country never reaches the larger centers of trade. As a result of these two demands the price of honey has risen to the highest figures recorded for many years, but during 1918 this has been influenced by the fact that there was a heavy loss of bees during the previous winter, resulting in a decrease in production in the eastern United States. This increase in price has acted as the greatest possible stimulus to the industry to increase production, the very thing which is so greatly needed if the industry is to do its share in the prosecution of the war. It is therefore safe to predict that the coming year will see the greatest effort ever made in furthering beekeeping.

The United States Food Administration has been of great help to the beekeepers in expediting shipments of honey and supplies for beekeeping, and especially in granting permits to beekeepers to buy sugar for feeding their bees where this was necessary.

The Bureau of Markets of this department has continued the issuing of the semimonthly market reports, and this has made it possible for the first time for the producer to get truthful information regarding the honey markets. This alone has been one of the chief factors making it feasible for this bureau to encourage beekeepers to increase their production. The continuation of the crop reports of the Bureau of Crop Estimates has also been of importance in this crisis in the industry.

The United States Fuel Administration was of service in permitting the chief factories for the manufacture of beekeeping supplies to run on fuelless days and in supplying one of these factories with coal at a serious time. The Post Office Department recently ruled that bees without combs may be shipped by parcel post, a ruling which materially helps in the proper distribution of bees whenever there is a serious loss in any part of the country.

Among the beekeepers of the country there has been an effort for organization for the better marketing of the crop, resulting in the forming of two large cooperative societies, both of which were assisted by the Bureau of Markets of this department. As has been indicated, there has also been a tendency for the beekeepers to organize for better education and mutual help.

The work of the bureau in bee culture during the year has therefore been chiefly a continuation of the campaign for increasing the honey crop of the country as a war measure, and to a large degree the regular investigations of the bee-culture section have either been curtailed or have been discontinued, except that on the diseases of bees, which is so important and so immediately applicable that it can not be stopped without great loss.

DEMONSTRATIONS IN BEE CULTURE.—Under the regular appropriation three men are assigned to extension work in cooperation with the regular extension service of the department and of the various States. There was also assigned to this office, from funds available under the food-production act, \$15,000, which was also applied wholly to extension work. Since this work was all conducted as one project, it is best not to attempt to separate it according to the two sources of funds.

The main feature of the extension work in beekeeping is an effort to increase the honey crop of the country as a food-production measure. The shortage of sugar has made it necessary to increase the supply of all the supplemental sweets, and none of them may be increased more economically and profitably than honey, and none of them is of more value as food. As has been pointed out in a statement from the Office of the Secretary (Circular No. 87), the amount of nectar which annually is permitted to dry up and thus go to waste far exceeds the amount of sugar of all kinds consumed by the American people, and this waste is of the highest economic importance, especially in time of war.

The first work in extension has been with those who already have bees, and no effort has been made to induce more persons to take up beekeeping. It has been shown clearly that it is unwise to encourage the keeping of bees generally, for the presence of the brood diseases, and especially the necessity of good care in winter, make beekeeping a branch of agriculture that demands specialization. However, it is realized that there must be provision for the making of beekeepers for the future, and the most promising methods seem to be through the clubs organized in connection with the extension work. In order that material may be available when it is needed, work has been begun on a program for a boys' club, and a series of special circulars is being prepared for use in connection with this program.

During the year 16 men have been employed in beekeeping extension work, and considerable additional field work has been performed by 4 men regularly employed in the Washington office. Three of these men have been called to the Army and six have resigned to take up commercial beekeeping, the present profits in beekeeping making it extremely difficult to maintain a regular force for this work. The first man appointed under the food-production act began work in November, 1917, so that most of the work has been during the last half of the fiscal year. During this time the field force has held 713

meetings of beekeepers in 34 States, reaching over 25,000 beekeepers, and, in addition, they have visited 1,198 apiaries and have given personal instruction to the owners regarding their beekeeping practices. An important part of the work has been the organization of the beekeepers in various counties into local associations for the betterment of beekeeping conditions. During the year 84 such associations were formed and plans are made for a considerable number of others to be perfected during the coming year.

An interesting and valuable phase of the extension work consists of reports on conditions pertaining to beekeeping in the various counties visited by the field staff. These are filed geographically and have already served as a valuable guide in planning the work of the field men. In time these reports, which are made incidentally as the men go about their work, will serve as a survey of the beekeeping conditions throughout the country. These reports are also furnished the extension divisions, thus making the information available to the State men engaged in the promotion of the beekeeping industry.

During the first part of the fiscal year a number of mimeograph circulars were sent to beekeepers direct, especially some urging that better care be given the bees during the winter. As the field force was enlarged this part of the work was discontinued, but it is believed that these circulars were the means of doing a great deal of good in calling to the attention of beekeepers the necessity of increasing the honey crop as a war measure. The practical advice given also served to bring about better conditions among those beekeepers who may be reached by that method, but obviously the personal contact of the field men is more effective.

In order to provide information regarding various practices of practical beekeeping two bulletins have been prepared during the year. Farmers' Bulletin 503 on comb honey has been revised and a new Farmers' Bulletin on the transferring of bees to modern hives (No. 961) has been issued. The latter bulletin will be especially applicable in certain parts of the country where modern methods have not been much practiced, but where the extension men have been at work. In view of the necessity of providing the field force with additional help and especially of the need of more practical literature on beekeeping, several additional popular bulletins are projected.

In addition to these publications there have been prepared during the year two publications showing the need of more honey during the war emergency. One of these appeared in the 1917 Yearbook of the department and another as Circular No. 87 of the Office of the Secretary. The Bureau of Crop Estimates also contributed a bulletin (Department Bulletin 685) giving statistics concerning the beekeeping industry which is of help in the same way. As a part of this phase of the work several press notices were prepared and also several papers for publication outside the department.

WINTERING OF BEES.—The investigational phases of this problem have largely been abandoned because of the press of work incident to the war, but practical observations have been continued which serve fully to substantiate the results of former years. The winter of 1917-18 was one of the worst ever recorded, and the loss of bees throughout the country was enormous, yet those colonies which had been prepared in accordance with the recommendations of the bureau

came through the winter strong in bees and were able to get the full crop during the summer. This was therefore a striking demonstration of the validity of the recommendations. The chief activity on this project has been the preparation of material for the use of the field staff on this subject, and these men have carried on a vigorous campaign to prevent future losses like that of last winter. Two additional bulletins (Farmers' Bulletins 1012 and 1014) on practical phases of the wintering problem were prepared.

DISEASES OF BEES.—This project has been continued without interruption, because of its immediate application to beekeeping practices. During the year a bulletin was issued on the control of European foulbrood (Farmers' Bulletin 975), placing for the first time a proper emphasis on the preventive measures to be taken. Another bulletin (Department Bulletin 671) was issued on the methods of laboratory diagnosis of the various diseases of bees and a paper was presented for publication on the so-called Nosema disease of adult bees. The spore-bearing organisms encountered in laboratory diagnosis have been described in a paper in the *Journal of Agricultural Research*.

The most important part of the work during the year was a series of field experiments on the behavior of European foulbrood in the hive during the time that it is being cleaned out by the bees. This served to throw light on the methods to be used in preventive treatment. The results of this work will be presented soon for publication. This marks a new phase in bee-disease work and promises to yield most helpful results.

WORK ON THE GIPSY MOTH AND BROWN-TAIL MOTH.

During the fiscal year ended June 30, 1918, the area along the outside border of the territory infested by the gipsy moth in the New England States has been thoroughly scouted and additional infested towns have been found, so that the total area in which the insect now occurs is 22,091 square miles, as against 20,211 square miles reported for the previous fiscal year. The increase in area by States was as follows: Maine, 938; New Hampshire, 468; Vermont, 154; Massachusetts, 112; and Connecticut, 307, making a total of 1,880. It will be noted that nearly half of the increase in infested area is in the State of Maine. This is in territory where it is extremely difficult to prevent spread of the small caterpillars, as the warm south and southwest winds tend to carry them each year beyond the infested border. The isolated colonies which have been found in previous years at Bratenahl, Ohio; Mount Kisco, N. Y.; Rutherford, N. J.; Lenox, Stockbridge, and Great Barrington, Mass., and Wallingford, Conn., have been thoroughly scouted, and the surrounding territory has been examined, but no infestation has been found. It is believed that the insect has been exterminated in these colonies.

Territory infested by the brown-tail moth has been reduced from 36,684 square miles in 1917 to 32,990 square miles in 1918.

FIELD-CONTROL WORK.—The control work in the field has been carried on in accordance with arrangements made with the officials in charge of similar work in the States concerned. The policy adopted some years ago of confining our efforts to the scouting

of towns adjoining the infested border and cleaning up the infested areas in two or three tiers of towns inside the border has been continued. Special attention in these towns has been paid to discovering and stamping out infestations on high elevations, as it is necessary to keep such areas free from small caterpillars if serious wind spread to new territory is to be prevented.

The new sprayers delivered this year are the most powerful that have yet been employed. It has been possible to spray areas on high elevations by locating the truck at the water supply and forcing the spray material in some cases through a mile of $1\frac{1}{2}$ inch hose. It has sometimes been necessary to maintain a pump pressure of 1,000 pounds in order to spray high elevations with such long leads of hose, but this has been accomplished satisfactorily and economically, when the loss of time and delay that would be experienced in hauling water such long distances is considered. Furthermore, in many cases hose lines had to be laid through woodland and rough areas where water for spraying could not be hauled.

Spraying operations were conducted in 40 towns during the month of June, as follows: New Hampshire, 22; Massachusetts, 10; Rhode Island, 1; Connecticut, 7.

PRESENT CONDITION OF THE AREA INFESTED BY THE GIPSY MOTH AND THE BROWN-TAIL MOTH.—It was apparent in the fall of 1917 that serious defoliation by the gipsy moth would result in many parts of the infested area. Conditions were particularly bad in the Cape Cod region in Massachusetts, but severe defoliation was looked for to a less extent in limited areas in other parts of the territory.

Climatic conditions during the winter were more severe than had been experienced in New England for many years. Unusually low temperatures were accompanied in many localities by abnormally low humidity. In most sections a heavy snowfall occurred about the 1st of December and in a large part of the territory the ground was covered with snow throughout the winter. This interfered seriously with field work.

The weather became very warm in May, which resulted in caterpillars hatching considerably earlier than during the two or three previous years. Later it was noted that many egg clusters which were fully exposed and which were not protected by snow or debris on the ground failed to hatch. This condition was investigated, and, while in certain sections it seems probable that egg parasites and other factors had brought this result, it is undoubtedly true that the abnormally severe weather during the winter caused a material reduction in the infestation in many localities.

The hatching of egg clusters was more perfect in the Cape Cod section in Massachusetts than in any other part of the territory, and severe defoliation resulted there during the summer. In some parts of the infested region where there was a minimum of snow protection combined with high altitudes the hatching was so deficient that spraying was not attempted. This abnormal condition, while reducing the gipsy moth infestation in some sections, may have had a similar effect in reducing the increase of some of the introduced natural enemies, particularly the egg parasites. Definite information on this phase of the problem can not be secured until later in the season.

EXPERIMENTAL WORK.—During the fall collections were made to determine the status of one of the egg parasites of the gipsy moth, *Schedius kuvanae*. The results were more satisfactory than heretofore, and it was possible to rear large numbers of this species and to colonize them in infested towns where this species had not been liberated previously. Nearly 2,000,000 specimens were released late in September and October.

In November collections were begun to determine the percentage of parasitism by *Anastatus bifasciatus*, a single-brooded egg parasite of the gipsy moth. The collections that were made in the regions where this parasite was first liberated gave the most satisfactory percentage of parasitism that had ever been secured. Material was collected for use in colonizing this insect the following spring, but, although the egg clusters were handled in the same manner in the laboratory as heretofore, the number of eggs producing live parasites was considerably less than had been secured in previous years, so that it was possible to liberate this spring less than 2,000,000 specimens. It is probable that both of these species will not survive in maximum numbers such severe winter conditions as existed during the past year. Further work later in the season will show how severe the mortality has been.

Parasitism by *Compsilura concinnata* averaged higher during 1917 than heretofore, and this species was reared from a number of native caterpillars that were not previously known to be hosts of this parasite. *Blepharipa scutellata*, a tachinid fly which parasitizes large gipsy moth caterpillars and emerges from the pupæ, was recovered in much larger numbers in the summer of 1917 than in any other year since its introduction.

A new method has been devised for breeding specimens of *Apanteles melanoscelus* for colonization, and it has worked out very satisfactorily. This species passes through two generations in the field, the first attacking the small gipsy moth caterpillars and the second destroying the nearly full-grown larvæ.

The Calosoma beetle has been found in limited numbers in many widely separated parts of the infested area, and is more abundant than usual in the sections that are badly infested.

There were no severe infestations by the brown-tail moth this summer, and there has been a corresponding decrease in the abundance of the imported parasites that attack this insect.

The work on diseases affecting the gipsy moth and brown-tail moth has been confined principally to an attempt to determine the abundance of the brown-tail moth fungus in the winter webs, study of the value of an unnamed fungous disease which has been found in eggs of the gipsy moth, and study and liberation of a bacterial disease which originated in Japan and attacks the gipsy moth caterpillars in the field.

Little evidence has been secured during the past two winters that the brown-tail moth fungus winters in any quantity in the webs of this insect. The investigations on the disease found in eggs of the gipsy moth have not progressed far enough to warrant conclusions as to the extent to which this disease is responsible for nonhatch of eggs. The study of the Japanese disease of the gipsy-moth caterpillars

has progressed so far that attempts have been made to colonize it in the field, but the results of these colonizations will not be apparent for another season. Data are being secured on the prevalence of the wilt disease of the gipsy moth, but it has not been as abundant or destructive to the caterpillars this year as heretofore.

Silvicultural investigations on the sample plots are being continued.

QUARANTINE WORK.—The inspection of forest and quarry products and nursery stock has been continued during the past year, although the volume of this material is not as large as that inspected heretofore. This is particularly true in connection with the shipments of nursery stock. From the number of gipsy-moth egg-clusters intercepted on material that was offered for shipment, it is evident that this work must be effectively and thoroughly performed if the insect is to be prevented from spreading to points outside the infested area.

SUMMARY.—The most severe infestation of the gipsy moth is at present in the Cape Cod district in Massachusetts. While the area infested by this insect has increased during the past year, the severity of infestation along and adjacent to the border is less severe than heretofore. The effectiveness of the imported parasites and natural enemies of both the gipsy moth and the brown-tail moth is increasing, although the severe winter conditions during the past year have been unfavorable to some of the species concerned. The area infested by the brown-tail moth has decreased materially, and the insect is not now seriously destructive except in limited localities.

Considering the area as a whole, conditions are favorable at the present time to bring about a marked decrease in the abundance and destructiveness of the gipsy moth.

